

**PUBLISHED PROJECT REPORT PPR929**

Smart Mobility Living Lab Shared Research  
Programme - Abridged Safety Case for  
Automated Public Road Trials in London

Authored by TRL

## Report details

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## 1 Introduction

Automated vehicles are central to the UK Government's industrial strategy because of the potential they represent for addressing several challenges facing urban areas including traffic congestion, vehicle emissions, commuting time and costs, and road traffic casualties. In purely monetary terms, the UK's market for connected and automated vehicles is estimated to be worth £52 billion by 2035<sup>1</sup>.

The Smart Mobility Living Lab (SMLL) is a co-innovation project, part-funded by Innovate UK, led by TRL and a consortium of partners with world-leading expertise in transport and technology. The SMLL will deliver the UK's most advanced real-world connected environment for testing future mobility technologies, services and business models. As part of the SMLL, the Shared Research Programme (SRP), which includes a variety of partner organisations from insurers and automotive to landowners and academia, has a specific remit to drive innovation, underpinned by appropriate evidence. To kick-start this innovation the SRP are undertaking automated vehicle trials within the SMLL to accelerate learning and meeting individual and shared research and development objectives.

The automated vehicle trials within the SMLL aim to collect data and enable testing of processes and infrastructure through running a successful trial as well as to validate the safe operation of the automated vehicle. These trials are planned for in two phases starting autumn 2019 and are led by TRL.

To ensure that the automated vehicles are safe to operate on UK public roads, key safety, cyber security and vehicle requirements have been satisfied. All automated vehicle operation on UK public roads is fully compliant with the Department for Transport's (DfT's) Code of Practice for testing automated vehicles<sup>2</sup>, and all UK road traffic laws and existing vehicle regulations. The Safety Case has been developed by TRL, who are independent safety assessors and authors of BS PAS 1881 and the safety case framework for test beds within the UK. The Trial Vehicle used for public road trials are type-approved category M1 vehicles and a Safety Driver is always present within the vehicle. All Safety Drivers are fully trained and competent for their role, with sign-off carried out and documented by the automated driving system (ADS) developer (StreetDrone).

Safety is the priority and the Safety Case has been developed by TRL in line with the Code of Practice as well as to meet the necessary legal requirements to conduct testing on UK public roads and secure insurance for the trial. The key purpose of the Safety Case is to manage and reduce the potential risks of trialling automated vehicle technology on public roads to as low as reasonably practicable (ALARP). This document is an abridged version of the full Safety Case. Its purpose is to provide a publicly available overview of the trials and approach to risk

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<sup>1</sup> Market forecast for connected autonomous vehicles. Transport System Catapult, July 2017.

<sup>2</sup> Code of Practice: Automated vehicle trialling. Centre for Connected & Autonomous Vehicles, February 2019.

management to give assurance that the trials will be conducted safely, and risks are appropriately managed.

This abridged Safety Case is freely available and provides members of the public with high-level information regarding the operational safety of automated vehicle trials conducted in London.

TRL are leading the trials, which are being conducted through the SMLL's SRP. The roles of TRL and other organisations involved in the trials are as follows:

- TRL – operating and managing the trials;
- DG Cities – conducting and managing the SRP members' research activities during the trials;
- StreetDrone – providing the automated driving system (ADS), Safety Drivers and Software Engineers for Trial Vehicle operation.

Information contained within this abridged Safety Case is related to several key topics applicable to operational safety:

- Risk assessment, evaluation and tolerability of risk decisions;
- Operational guidance and incident response;
- Trials staff (including Safety Drivers) selection, training, roles and responsibilities;
- Vehicle platform and Automated Driving System (ADS);
- Route selection, safety assessment and controls;
- Compliance with the DfT's Code of Practice for testing automated vehicles, UK vehicle standards, and UK driving rules and road traffic laws.

The Trial Vehicle is an all-electric Nissan eNV-200 Combi. The Trial Vehicles' standard build and modifications are described in Section 5.



**Figure 1: SMLL Trial Vehicle**

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## 1.1 Trial aims and objectives

The broad aim of Phase 1 trials is to successfully run a trial, in line with the Safety Case, of an automated vehicle in a public domain which is capable of gathering relevant information from the Trial Vehicle itself by observation, sensors and cameras, as well as external infrastructure. This raw data will be made available, through SMLL, to their SRP partners to inform the development of further automated functionalities and supporting systems.

## 1.2 Synopsis of the trials

The trials will be conducted on privately-owned public roads within the Royal Arsenal development in the London Borough of Greenwich.

The automated vehicle trialling will take place on selected roads at the Royal Arsenal. These trials are planned in two phases:

- Phase 1 will involve the vehicle following the defined route and stopping at identified stops, but not collecting any passengers;
- Phase 2 will (subject to findings from Phase 1) allow members of the public to embark and disembark the vehicle at the demarcated stops on the route.

## 2 Operational Design Domain

Operational boundaries, known as the Operational Design Domain (ODD), define the conditions under which the vehicle can safely and reliably operate according to its automated functionality, without intervention from the Safety Driver. Trial activities must be paused if the boundary of the ODD is exceeded and checks against ODD requirements executed, with any changes or updates to the ADS carried out in accordance with the change control process.

The on-board Safety Driver, Software Engineer and Steward will undertake dynamic checks (e.g. for traffic, pedestrians, etc.) before and during trial runs. Safety Driver best practice and behaviour is compliant with both the UK Highway Code and road traffic law.

Extensive testing in a controlled track testing environment has been conducted to demonstrate that the Trial Vehicle performs in line with expectations and can safely negotiate the ODD.

## 3 Safety and risk management

### 3.1 Methodology overview

The operational Safety Case, which is separate to this document, outlines how StreetDrone safely operates its automated vehicle on public roads at the Royal Arsenal and provides the body of evidence to document the progression of testing and demonstrate that the vehicle is safe and reliable within a defined ODD. The operational Safety Case also demonstrates the following requirements to ensure that the trials are safe:

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- A robust risk assessment identifying hazardous scenarios, potential causes, person(s) impacted and mitigations implemented to ensure all risks are reduced as low as reasonably practicable;
  - Compliance with current legislation, standards and guidance; and
  - Provision of the required evidence and reassurance to the London Borough of Greenwich, and to both the trial and vehicle insurers.

The operational Safety Case is a live, managed, version-controlled document based on a comprehensive risk assessment, with supporting evidence for each of the risk decisions made.

The key operational risks related to the trials identified from the risk assessment include:

- Collision with pedestrian;
- Collision with trials team member;
- Collision with cyclist;
- Collision with motorcyclist;
- Collision with another vehicle;
- Collision with infrastructure;
- Collision between vicinity vehicles;
- Safety Driver distraction and/or fatigue;
- Injury to trials team member from Trial Vehicle or infrastructure;
- Data and cyber security breach.

Appropriate mitigations have been implemented to ensure that all risks identified are reduced to a tolerable level throughout the trials.

Monitoring, reporting and continuous improvement are embedded in the Safety Case and all on-road operations through TRL's Safety Case and associated operational guidance for the trials team. Data capture will take place for all manually-driven data gathering runs and automated trialling. All incidents and near misses will be monitored, reported and analysed throughout the trials to ensure continuous improvement and to assure the safety of all affected parties throughout.

Compliance with existing legislation, standards and guidance also forms an essential part of the Safety Case and is evidenced appropriately in the full Safety Case. TRL's compliance with the DfT's Code of Practice is discussed in Section 7.1, and compliance with UK road traffic law and vehicle assessment is covered in Sections 5 and 7.2 respectively.

Before automated vehicles can be safely and successfully integrated into urban road networks, in-depth track testing must be carried out. The Trial Vehicle's Automated Driving System (ADS) has undergone a thorough programme of testing and analysis in controlled environments prior to on-road tests, including simulations, track testing, and functional safety analysis. The ADS has been developed and tested by StreetDrone using their Renault Twizy platform, and validated by further analysis and track testing with the Nissan e-NV 200 platform, which will be used in these trials.

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## 3.2 Incident response plan

TRL has produced the following documentation for the trials which outline the actions to take in the event of an incident or emergency, including:

- Emergency response plan – developed in consultation with the SMLL, Royal Arsenal and emergency services to ensure incidents are dealt with promptly, safely and effectively;
- Incident and near miss reporting procedure - to ensure all incidents and near misses are reported and investigated and that any future mitigating actions are implemented.

All incidents and near misses will be monitored, reported and analysed throughout the trials to ensure continuous improvement and to assure the safety of all affected parties throughout. All personnel involved in the trials will be fully briefed on what to do in the event of an emergency both in terms of responding to the incident and reporting it to the appropriate parties. Safety Drivers, Software Engineers and Stewards, all of whom will always be on-board the vehicle during trials, will decide when to suspend or abort automated sessions based on predefined abort criteria.

## 4 Trials Staff

### 4.1 Roles and responsibilities

A fully-trained, experienced and competent **Safety Driver** will always be present in the driver's seat of the Trial Vehicle during the trials when the vehicle is in motion. The Safety Driver has received appropriate training from StreetDrone on the use and capabilities and limitations of the Trial Vehicle and systems. The Safety Driver will be ready, able, and willing to resume control of the vehicle at any time and will safely pilot the vehicle in manual mode as required. Relevant competence and experience will be proven before any trial activities.

The Safety Driver will always be accompanied and supported while piloting the Trial Vehicle by a **Software Engineer** in a rear passenger seat. The Software Engineer will be responsible for monitoring the vehicle systems during automated mode to ensure they are functioning correctly, and to identify potential cyber security threats.

The **Trial Manager's** role will be to manage the day-to-day running of the trials, including staff and vehicle operations. The Trial Manager will be available on-site at all times and will manage the trial activity throughout the day. In the event of an emergency, the Trial Manager will act as the Incident Manager.

A **Steward** will be present in the front passenger seat of the Trial Vehicle at all times. The Steward will be responsible for monitoring and recording any incidents or near misses, with a time stamp for full incident and near miss report completion by the Safety Driver at the end of the trial session.

One or more **Marshals** will be present along the route to monitor and report any hazards and to answer any queries from members of the public.



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A **Safety Manager** from TRL's safety and risk management team will provide daily on-site support initially, followed by daily on-call assistance, to support the Trials Manager and to ensure operations are running correctly and safely.

The **Data Manager** will be responsible for ensuring that data collected by the Trial Vehicle is safely and securely collected, downloaded and stored.

## 4.2 Selection and training

All Safety Drivers are fully trained by StreetDrone to ensure they are competent and experienced with the Trial Vehicle and its systems and sensors, including their capabilities and limitations. Documentation has been prepared detailing Safety Driver selection, policies on Safety Driver distraction and fatigue, training of the StreetDrone team members, policies on team responsibilities, and how to safely operate the vehicle and ADS.

TRL will be responsible for providing suitably trained, competent and experienced Stewards, Marshals, Safety Managers and Data Managers. All members of the trials team will receive necessary training for their specific role(s) in the trials. They will also attend daily safety briefings prior to trial operations.

## 5 Vehicle and automated driving system

The trial vehicle is a 2019-plate all-electric Nissan eNV-200 Combi with automatic transmission, which is a minibus-style vehicle with seating for up to seven people, including the driver; all seats are fitted with seatbelts.

The Nissan has been modified by StreetDrone to enable automated control of certain driving functions using a drive-by-wire system, sensors, and a custom ADS software stack. The bodywork of the vehicle has also been modified by StreetDrone to facilitate testing and development: modular sensor mounts are provided, and a roof rack and Lidar mount have been integrated to the roof to allow mounting of equipment.

## 6 Route selection and assessment

The trial route is situated in the Royal Arsenal and is less than 1 mile (1.6km) in length. The trial route will utilise privately-owned public roads within the Royal Arsenal development in the London Borough of Greenwich. These roads are privately-owned by the Royal Arsenal, who have granted permission for these trials to take place. The route has been selected following a process designed to assess its suitability for the trials, in terms of both safety and practical considerations. Those consideration comprised, but were not limited to, the following:

- Road type and road users;
- Speed limits (the entire route, and Royal Arsenal development, has a maximum 5 mph speed limit);
- Hazards (or potentially hazardous) features/scenarios;

- STATS19<sup>3</sup> collision data, particularly numbers, locations and types of killed and seriously injured collision records; and
- Consultation with the Royal Arsenal and Transport for London.

## 7 Compliance

### 7.1 DfT Code of Practice

This abridged Safety Case, and all trial activities, are compliant with all relevant requirements of the DfT's Code of Practice<sup>4</sup> which provides guidance for any organisations wishing to conduct the testing of highly or fully automated technologies in public places.

The DfT's Code of Practice lists the following key requirements for undertaking trials of automated vehicle technology in the UK:

- A driver is present, in or out of the vehicle, who is ready, able, and willing to resume control of the vehicle;
- The vehicle is roadworthy;
- Appropriate insurance is in place.

These key requirements will always be met during the trials. In addition to these requirements, Safety Drivers will always be expected to adhere to all operational guidance documents developed by TRL for this particular trial and all relevant rules and regulations for driving on public roads in the UK. TRL have carried out a desktop compliance assessment to ensure compliance with the Code is achieved throughout all trial activities.

### 7.2 Vehicle assessment

The Trial Vehicle is compliant with all appropriate vehicle standards. Since it is under three years old, it does not require a MOT certificate. The Trial Vehicle is type-approved, and any systems added to the Trial Vehicle do not invalidate the type approval process nor the use of standard vehicle controls for a human driver. Driver field of view from the vehicle cabin is unaffected. The Trial Vehicle also meets the relevant conditions of the Road Vehicles (Construction and Use) Regulations 1986, as detailed in the DfT's Code of Practice.

### 7.3 Cyber security standards

A cyber security and sabotage assessment has been undertaken by StreetDrone to assess risks in these specific areas and develop mitigations where required to maintain risks at tolerable levels. The assessment considers scenarios in which a potential saboteur would have physical access to the vehicle (and its systems/equipment), and scenarios in which access to the

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<sup>3</sup> STATS19 is a form used to report injury accidents on Great Britain's public roads to the Police.

<sup>4</sup> Code of Practice: Automated vehicle trialling. Centre for Connected & Autonomous Vehicles, February 2019.

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vehicle (and its systems/equipment) is gained via remote means. Mitigations are fully compliant with the DfT's Code of Practice.

#### 7.4 Data protection

A full Data Protection Impact Assessment has been conducted to ensure the correct processes are in place and compliance with legislation is achieved. More information can be found here: <https://www.smartmobility.london/cctv-privacy-policy>

### 8 Safety and insurance for public road testing

Insurance cover is in place for the Safety Drivers, Trial Vehicle and the ADS equipment on and within the Trial Vehicle for the duration of the trials. The trial activities are also insured under TRL's business insurance.

### 9 Points of contact

Any questions relating to this public version of the abridged Safety Case should be referred to TRL's points of contact:

Camilla Fowler, Head of Risk Management; [cflower@trl.co.uk](mailto:cflower@trl.co.uk)

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## Smart Mobility Living Lab Shared Research Programme - Abridged Safety Case for Automated Public Road Trials in London

TRL's mission is to enable world-class transport and mobility solutions to improve road safety and efficiency. TRL shares the UK Government's vision to eliminate fatalities and serious injuries on UK roads, and believes that this can be achieved through innovation and development of new technologies including connected and autonomous vehicles. That's why, with funding from Innovate UK, TRL are setting up the Smart Mobility Living Lab - the UK's most advanced real-world connected environment for testing future mobility technologies, services and business models. TRL have partnered with a variety of organisations to undertake this task including insurers, manufacturers, landowners and academics under the Shared Research Programme. To kick-start this innovation, the SRP are undertaking automated vehicle trials within the SMLL this year.

This trial will see an automated vehicle developed by Streetdrone driving itself along a predefined route in London, intending to prove the safe deployment of the technology as well as collecting valuable research data. Safety is TRL's number one priority when testing new technologies in the public domain. This abridged Safety Case is freely available to the public and has been written to demonstrate that the trial is being conducted safely and legally, and that the potential risks of trialling automated vehicle technology on public roads are managed and reduced to acceptable level.

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